THE WARRIOR

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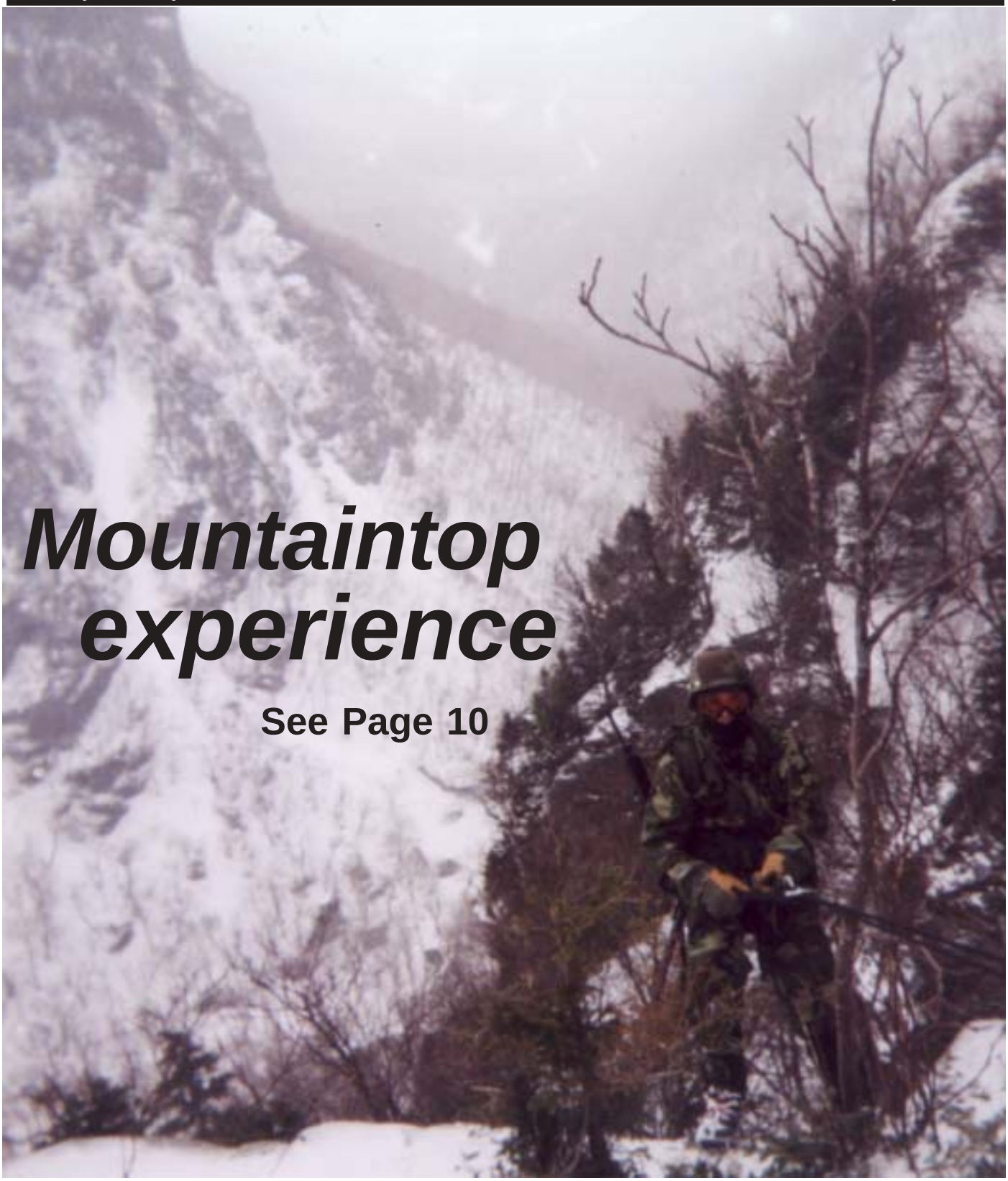

Mountaintop experience

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Cover photo: Chris Shaffer, a materials engineer with the Chemical Technology Team, starts to rappel down a mountain at the Mountain Warfare School in Jericho, Vt . (Courtesy photo)

THE WARRIOR
U.S. Army Soldier Systems Center

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Cool relief for first responders

A new personal cooling system for emergency responders working in encapsulated protective suits is the goal of a Cooperative Research and Development Agreement between the U.S. Army Soldier Systems Center (Natick) and the Oklahoma City National Memorial Institute for the Prevention of Terrorism (MIPT).

The Institute and an Oklahoma State University (OSU) team are in partnership with Natick to improve protective clothing for police officers, firefighters and medical personnel responding to terrorist incidents.

The three-year, $3 million project will design and build a personal cooling system for work in areas affected by chemical, biological or nuclear weapons. The overall objective is a wearable cooling system that will reduce the effects of heat stress on emergency responder performance.

The MIPT is a non-profit organization that sponsors research on equipment, training and procedures to help first responders prevent or respond to terrorism.

Gen. (Ret.) Dennis Reimer, MIPT director, said he knew about Natick's capability in designing and testing military protective equipment and after some correspondence became "convinced" that the facility has the know-how that can be transferred to the first responder community.

"We at MIPT are extremely pleased to be associated with the professionals at Natick, and at our first year-in-progress review we saw how much we were able to leverage the experience and expertise of (the Soldier Systems Center)," Reimer said.

Some commercial personal cooling garments use ice packs inserts, which cool unevenly. Under this MIPT program, a new technology called adsorptive carbon-based cooling will be developed using a new kind of cooling system to solve these types of problems.

"Adsorptive carbon-based cooling is something we're aware of, but we haven't done research and development on it," said Bill Haskell, technical program development manager for the National Protection Center at Natick. "This project is investigating a technology the Army could leverage for future warrior systems."

The portable, integrated cooling system will include a liquid-circulating garment developed at Natick and be powered by a battery for a one-hour mission. Average body heat dissipation is pegged at 200 watts in an 80-degree F environment.

Courtesy photo

First responders answering calls with hazardous materials will get a new personal cooling system that lasts longer and cools evenly.

Haskell is serving as the technical program manager for MIPT for the project, providing a link with the Army's protective clothing research program. Although not involved in actual research and development, Natick is acting as a consultant. The successful development of protective clothing directly benefits the emergency response community and the military.

"(Natick) can do these type of projects for organizations outside the military," Haskell said. "We're leveraging expertise and equipment from the Soldier Systems Center."

The National Protection Center will provide data and expertise related to thermoelectric cooling, electrolyte materials and materials flammability to the Protective Clothing Project investigators. Natick has in-house scientific, engineering and program management expertise in the area of protective clothing development.

"We have meetings every few months to tell them what looks good, what looks bad as they move the project along," said Walter Teal, a chemical engineer with Natick's Chemical Technology Team. Teal has been working on microclimate cooling systems for nearly 15 years.

Dr. Donna Branson at OSU heads the Protective Clothing Project contractor team, with support from Sciperio Inc., SRI International, Inc., MesoSystems Technology, Inc., and Nanopore Inc., and faculty at OSU, Johns Hopkins University and Clemson University. Funding is being provided by MIPT through the National Institute of Justice.

"Today's (weapons of mass destruction) suits are bulky, heavy and hot," said Branson. "Our research will make a protective system that will be thinner, lighter and cooler than the current systems, and that will increase the effectiveness of responders."

A prototype cooling system is scheduled to be ready by April 2003.

Adaptable 'skin'

Hydrogel changes wet suit's water flow for better protection

By Curt Biberdorf
Editor

Divers may one day have a wet suit that automatically adapts to prevailing environmental and operational conditions for improved thermal protection.

The new wet suit uses "SmartSkin," a patent-pending technology that represents a disruptive technological advance in wet suit fabrics. SmartSkin works by adjusting the permeability of the fabric's inner layer through the action of a thermally-sensitive polymer hydrogel.

The gel transforms the suit into a thermally-activated flow control system, which permits increased flow of water through the wet suit material when the diver is warm, but expands to cut off flow when the diver's skin temperature drops below a preset threshold temperature. The effect is regulation of skin temperature in a wide range of diving conditions.

The product, funded through the Small Business Innovative Research program, is a joint development effort between Midé Technology Corporation of Medford, Mass., the U.S. Special Operations Command of MacDill Air Force Base, Fla., and the U.S. Navy Clothing and Textile Research Facility, an installation partner at the U.S. Army Soldier Systems Center (Natick).

"The Special Operations Forces were interested in exploring technologies to protect surface swimmers from cold water exposure," said Cleveland Heath, a textile technologist at the Navy facility. "The ultimate goal of the project was to create an ensemble for operations in extreme environments capable of transitioning from a water to land environment with no external power. They knew we had a hydro-environmental simulator and submersible instrumented thermal manikin, capable of quantifying the benefits of any technological advancements for in-water applications, so approaching the Navy was a logical choice to fulfill their need."

A dry suit offers divers the best protection in cold water by totally encapsulating the wearer and maintaining an insulative air layer, but it is bulky and requires skilled use.

A semi-dry suit offers the next best level of protection by using rubber seals at the neck, wrists and ankles. Unfortunately, the seals tend to be tight and uncomfortable and, because these suits are so good at preventing flushing, divers often overheat in warmer conditions.

Although traditional wet suits protect at a lower level, they tend to be more comfortable because they lack tight seals. In addition to the insulation value provided by the base material, these suits offer thermal protection by limiting flushing through close fit over the entire body.

Courtesy photo

It looks like an ordinary wet suit, but the SmartSkin suit protects the user under a wider range of water temperatures.

Mimicking the contours of the body to ensure close fit is difficult, meaning that gaps and voids, particularly in areas of drastic shape change such as joints, are unavoidable. Motion causes the volume of these cavities to change and the suit acts like a pump. The flushing of water through the suit results in a continuous loss of body heat through forced convection, a mechanism that is responsible for up to 60 percent of the total heat loss.

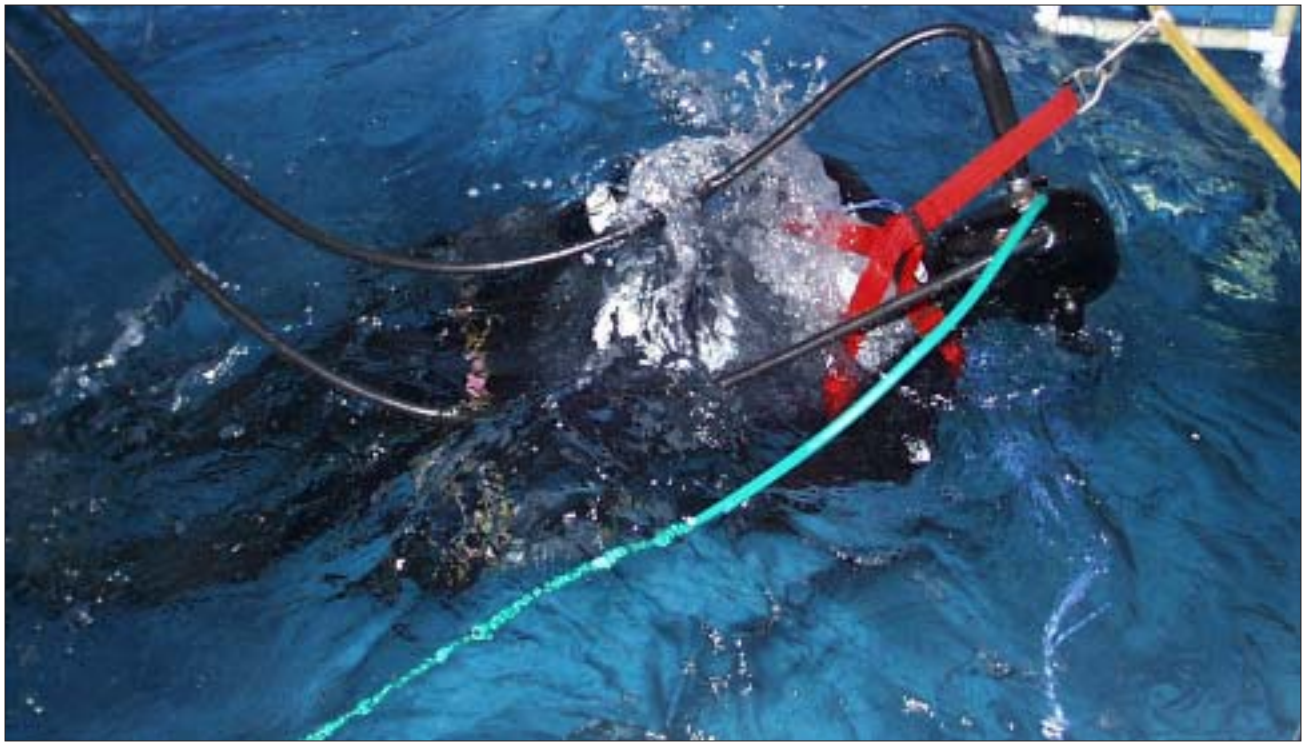
"It is here that the opportunity exists to improve the fundamental function of the ordinary wetsuit," said Marco Serra, senior engineer and project lead at Midé Technology Corporation. "If the rate at which water flushes through the suit can be controlled, the temperature of the diver can be regulated."

With SmartSkin, the hydrogel absorbs water and expands, reducing the permeability of the inner foam layer. This creates a seal, trapping the heated water layer inside the suit and making it difficult for additional water to flush through.

"The beauty of the system is that if the trapped water becomes too warm and the diver begins to overheat, the system reverses—water is expelled from the hydrogel, the foam reduces thickness and the flushing exchange begins again, thereby cooling the wearer," Heath said.

Heath is the contracting officer's technical representative for the project. He said Midé's original goal was to increase thermal protection as the composite fabric became thicker with decreased water temperature.

After Heath suggested that Midé explore using the hydrogel as a mechanism to control flushing, Midé identified the results of a laboratory



Courtesy photo

NCTRF's hydro-environmental simulator performs instrumented tests on a thermal manikin wearing the SmartSkin suit. The facility is capable of quantifying the benefits of any technological advancements for in-water applications.

study that confirmed this was the way to go. Initial laboratory experiments were conducted, demonstrating that water flow could be regulated using the novel technology in this application. Consequently, Midé developed the SmartSkin composite fabric into its current form.

The resulting SmartSkin suit looks like a conventional wet suit. The outer skin, which provides structural integrity, is made of closed-cell neoprene foam typical of wet suits. The inner layer contains the active material.

Although much of the suit is still made in the same way as ordinary wet suits, portions use the composite SmartSkin fabric, which is strategically placed in the torso, forearms and calves to control water movement within the suit.

In October 2001, Midé compared the performance of a SmartSkin prototype suit to that of a conventional suit using the Navy facility's submersible, instrumented manikin. Since the concept relies on water flushing through the suit, tests were done using the facility's wave generator.

In this test Midé successfully demonstrated SmartSkin's ability to alter the thermal protection capabilities of the suit and adapt to environmental conditions.

"Manikin testing quantified the results to prove the concept before we could recommend an optimum configuration for user testing," Heath said. "We tested suits with no hydrogel, all hydrogel and partial hydrogel. Using partial hydrogel to strategically control the flushing gave us the desired results with the minimum use of hydrogel-laden foam."

When tested in warm water, the two suits offered nearly the same protection.

However, in cold water, SmartSkin provided a 70 percent improvement. As a result of the manikin data, Midé envisions being able to significantly reduce the thickness of the outer layer of neoprene, thereby improving mobility and reducing garment weight.

The hydrogel for the SmartSkin prototype tested on the manikin was engineered for freshwater. Since the gels react differently depending on the surrounding environment, a second saltwater version of the hydrogel was subsequently produced. Indications in the laboratory have confirmed that the saltwater hydrogel behaves as well as the original prototype hydrogel, according to Heath.

"SmartSkin suits allow surface swimmers and divers to operate in a wider range of temperatures without having to possess a range of suit thicknesses," Serra said. "Divers and surfers in particular would find it helpful, although we would be looking at designs optimized for each application to take specific needs into account. The two activities are very different, and it is important to recognize that when designing the product."

Other potential markets include the Navy shipboard community and commercial fishermen, where the technology could be adapted to survival suits for accidental immersion. Midé is seeking funding to move to the program's final phase of commercialization and explore further application possibilities.

"Although we remain cautiously optimistic, there's enough interest from the user-community to recommend follow-up funding to further the technology, and certainly an opportunity for recreational use in a market which has not seen a realistic technological advancement in many years," Heath said.

Unscripted

Simulation center retools for Objective Force Warrior

By Curt Biberdorf
Editor

Beginning this fall, the Integrated Unit Simulation System (IUSS) at the U.S. Army Soldier Systems Center (Natick) will emerge with an innovative architecture bringing groundbreaking modeling and analysis capabilities to help the Army transform to the Objective Force.

"We're doing things never done before. We're out there on the forefront in human behavior representation," said Dale Malabarba, Modeling and Analysis Team leader.

The IUSS is a constructive force-on-force model for assessing the combat worth of systems and subsystems for both individual and small unit dismounted warriors in high-resolution combat operations.

For more than a decade, analysts have used the IUSS, which has a computer-based software that gives analysts the primary capability to model lethality and survivability, and a more limited capability to model command, control and communications; mobility; sustainability and Military Operations in Urban Terrain. It is acknowledged as the optimal tool for highly detailed research, development and acquisition analyses of individual warrior systems.

On their own

IUSS will soon boast advanced cognitive models that will allow computer-generated forces, within combat vignettes developed by the analyst, to behave more like real soldiers. They will move, shoot and communicate more independently than ever before. Also, they will sense their environment around them, drawing critical cues from visual and auditory algorithms, and then make decisions based on their perceived ground truth.

Current combat simulations have to be mostly scripted. Analysts predetermine the path computer-generated forces must take to their objective and "hardwire" certain tasks to be performed along the way. The new IUSS will enable the forces to operate autonomously and choose their path and actions based on a dynamic battlefield, said Malabarba.

The newest IUSS will also have a simple-to-operate graphical user interface, a cutting-edge 3-D viewer, enhanced and destructible terrain, and improved lighting and weather conditions.

Accomplishing this feat takes a team of people that extends beyond the Soldier Systems Center. Industry partners, such as Simulation Technologies, Inc. and Charles River Analytics, are leading the charge in

Advanced cognitive models will allow computer-generated forces, within combat vignettes developed by the analyst, to behave more like real soldiers.

making IUSS a "thinking machine" with a robust plug-and-play backbone that will accept improved computer code as it becomes available.

Government partners, such as the Army Materiel Systems Analysis Activity and the Army Research Laboratory, are assisting the Modeling and Analysis Team by collecting, identifying and prioritizing significant human performance data that accurately represent soldiers in MOUT and other close combat situations.

Costs vs. benefits

"We have significant data gaps for basic human performance and human factors. For instance, we don't know the process of acquiring a target in urban combat," Malabarba said.

Driving a shift in the modeling and analysis community is the Army's concept for the future battlefield that features sensors and advanced communications. Air, ground and body sensors will channel information into the command and control post, be translated and then relayed back to the warriors in the field.

"We have a soldier, a squad on the ground. What are we going to tell them? What's the most effective way to do that?" Malabarba said. "What we're trying to get to is a system that takes in variables we haven't been able to consider previously."

Another problem the Modeling and Analysis Team is studying is balanced selection. Soldiers have a wide range of choices of what to bring and how to pack it on a mission.

"Right now, it looks like the platoon sergeant determines what to bring, but it would be nice to have some quantitative data to say what's best under different situations," Malabarba said.

Modeling and analysis is also helpful in finding out the cost vs. benefits of a soldier item and assist product managers in developing standards for varying capability levels. For instance, with body armor, simulation trials could span from the soldier wearing no armor to full plating. Maybe a design with minimal coverage is all that is needed if the soldier is going to see the enemy first given improved sensor technology, but a soldier's comfort level and mobility also need to be considered.

"Just because you could doesn't mean you should," Malabarba said. "I want to choose something that improves performance in real conditions."

The Modeling and Analysis Team also supports the Department of Defense Combat Feeding Program with the Dynamic Nutrition Model and Ration Selection Program, and is developing the Integrated Casualty Estimation Methodology with the Army Materiel Systems Analysis Activity to help build better weapons and protection against weapons.

Global reach

The IUSS uses these tools as a measure of performance, and more importantly, effectiveness. Malabarba also intends on leveraging the work being done in Australia, Canada, Netherlands and United Kingdom toward the goal of designing the optimal soldier platform.

"Foreign armies have their own version of Land Warrior and Objective Force Warrior. They are asking the same questions and share a common set problems," Malabarba said. "The re-architecture will enable us to share the work and benefits."

For product managers, team leaders, and other potential customers, the Modeling and Analysis Team is available to provide expert assessment of their items for specific areas. "We can take a problem and run it through our models to see how best to solve it," Malabarba said. "We're here to support the product manager, passing along information to our clients like a contractor."

Editor's Note: Mike Statkus and Sandra Fisher with the Modeling and Analysis Team contributed to this story.

Simulation improvements will better represent soldiers in MOUT and other close combat situations.

Electrified

Program explores ways to manufacture wired clothing

By Curt Biberdorf
Editor

Future warrior systems include heads-up displays, global positioning systems, combat identification sensors, chemical detectors, electronically-controlled weapons and physiological status monitors connected to the warfighter's computer for instant information access.

A manufacturing technology program at the U.S. Army Soldier Systems Center (Natick) is exploring ways to integrate electric wires and fiber optics into textile materials that will enable future warfighters sophisticated battlefield capabilities without the weight and bulk.

Warrior/Underhill

An electric wire integrated into a helmet cover would be connected to another part of the uniform.

Several production-based manufacturing processes are being investigated to develop the techniques needed to support mass production capabilities of electro-optic textiles, said James G. Fairneny, an electrical engineer and project manager for Manufacturing Processes for Integration of Electro-Optic Conductors and Devices Into Textiles at Natick.

"The goal is to provide the warfighter with executable functions that require the fewest possible actions on his or her part to initiate a response to a situational combat need by means of intelligent textiles," he said.

Cooperation between Natick Soldier Center's Individual Protection Directorate and the Objective Force Warrior Technology Program Office, Communications and Electronics Command at Fort Monmouth, N.J., and several other military, academia and industry groups are involved with various textile-based projects to make it possible.

Warrior/Underhill

A helmet cover turned inside out shows how an electrical wire can be embedded in fabric through stitchless seam technology.

Invisible antenna

A multi-frequency antenna vest is being worked on by researchers at the Naval Postgraduate School in Monterrey, Calif., as one option to eliminate the antenna troops now carry. The antenna will provide coverage in the 30-500 MHz and 300-2,000 MHz frequencies using an ultra-wideband antenna with no visual signature.

Similarly, a prototype to replace the antenna for the low-frequency band SINGARS radio was built into a fabric vest by BAE SYSTEMS Aerospace Inc. Manufacturing technology examined the fabrication and feasibility of building transmission lines and radiation elements for the wearable textile-based antenna.

Clean connection

Existing round plug-ins for the cabling on the Land Warrior's computer are bulky, costly and prone to failure because of the fragile pin and socket connection, said Fairneny.

Exponent in Natick and Thor Electronics Inc., in Salinas, Calif., are working to upgrade the network cables and manufacture a flat, pinless connector with recessed contacts. This connector uses flat pieces of metal that can easily be designed in 11, 21 and 31 pinless contacts for various cable configurations as a small and flat connector. The setup dramatically reduces the cost of existing custom connectors now used by Land Warrior.

The prototype ultra-low-profile rectangular connector system has a plug and receptacle in controlled-force breakaway and quick disconnect configurations, and can be used in a fabric-based bus or conventional cables.

Leaner and lighter yet rugged, the connector eliminates the expensive pin and socket assembly process. It meets military requirements for environmental and electrical compat-

ibility, and parts are domestically available and made in high volume.

Additionally, the American Competitive Institute (a consortium of industry and academia) in Philadelphia will investigate alternative components for flat body conformal connectors and cables. Several commercial-off-the-shelf products are being considered with concept designs to modify the manufacturing process to lower product costs.

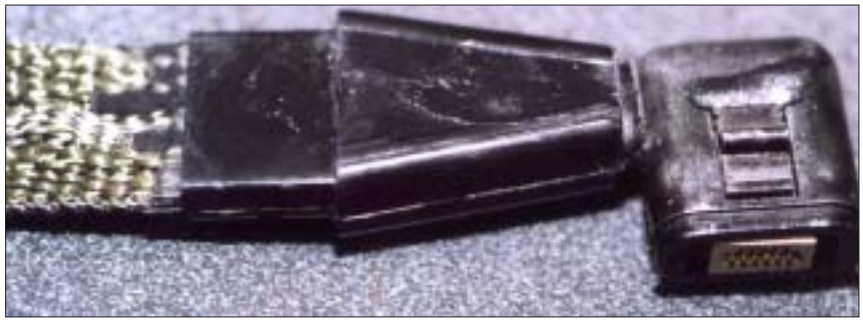
Electrical testing and environmental evaluation is being conducted on modified and all-new products.

Blended fibers

One way of removing external wires and creating a more distributed network of sensors and electronics is to weave the wires right into the fabric.

Photonics Laboratories, Inc. in Philadelphia and the Philadelphia School of Textiles have a contract to develop manufacturing processes for integrating optical fibers and traditional wires into woven and knitted textiles. With these technologies, conductors and optical-electronic systems could be weaved into soldier's uniforms during large-scale manufacturing.

"They're looking at the physical interaction of wires or optics as it goes through machinery," Fairneny said. Textile structures are physically and mechanically different from fiber optics or wires. "Fiber optics bent too much will break, while metal wires don't bend back and can get fatigued."



Warrior/Underhill

A new connector should reduce the cost of existing custom connectors now used by the Land Warrior system.

At the Philadelphia School of Textiles, researchers are investigating the mechanical motion of textile fibers so that it's possible to make modifications to incorporate fiber optics and conductive wires. Mechanical parts that produce sharp bending were identified for potential change as well as looking at a variety of fiber optics most able to handle bending.

Entrapped

Another way of incorporating electrical networks into soldier clothing is through stitchless seam technologies that were first developed by Clemson University with prior Natick Mantech funds.

The technique entraps fiber optics and conductors either on top of or along the seam of the fabric. Clemson Apparel Research at Clemson University in Pendleton, S.C., is investigating combinations of wires to form the electrical characteristics of commercial cables, available connectors, and garment-to-garment and undergarment-to-garment mechanisms.

"One difficulty will be trying to connect the top to the bottom for a complete uniform network," Fairneny said.

Clemson is considering the specific network needed for Land Warrior laser sensors on the helmet cover and a general network for the Battle Dress Uniform (BDU) top. The first samples of fabric containing electrical wires and a helmet cover network have been provided.

Fiber keyboard

In a move to eliminate bulky and heavy gear, such as Land Warrior's soldier control unit, WRONZ EuraLab in the United Kingdom was contracted to develop a soft switch fabric with the required sensitivity to be operational on the sleeve of a BDU and seamless incorporation into the garment.

"The keyboard would be pressure-sensitive, not touch-sensitive, for use on the battlefield," Fairneny said. "Land Warrior's soldier control unit is a box that sits on the chest. It would be better to integrate that into the clothing for reduced weight."

One goal is to produce a keypad on the sleeve that can interface as the soldier control unit with specific military functions. A textile data bus and necessary connectivity to transport the signal from the keyboard to the control electronics is another goal.

Fairneny said an initial prototype is expected to provide three or four keys needed for a few simple commands to prove the concept.

Further development should lead to a BDU housing to hold the electronics and a fabric-based display.

Graphic by Steve Smith

A keyboard built into a uniform sleeve is a way to remove bulky control units from a soldier's load.

In northern Vermont, two Natick engineers graduated from the winter phase of an Army school to qualify them as...

Mountain Men

Two U.S. Army Soldier Systems Center (Natick) engineers completed the winter phase of the Vermont Army Reserve and National Guard Mountain Warfare School at Camp Ethan Allen in Jericho, Vt., in February and March.

Phil Gibson, a materials research engineer with the Materials Science Team, and Chris Shaffer, materials engineer with the Chemical Technology Team, earned the Ram's Head Badge awarded to those who successfully complete the summer and winter phases.

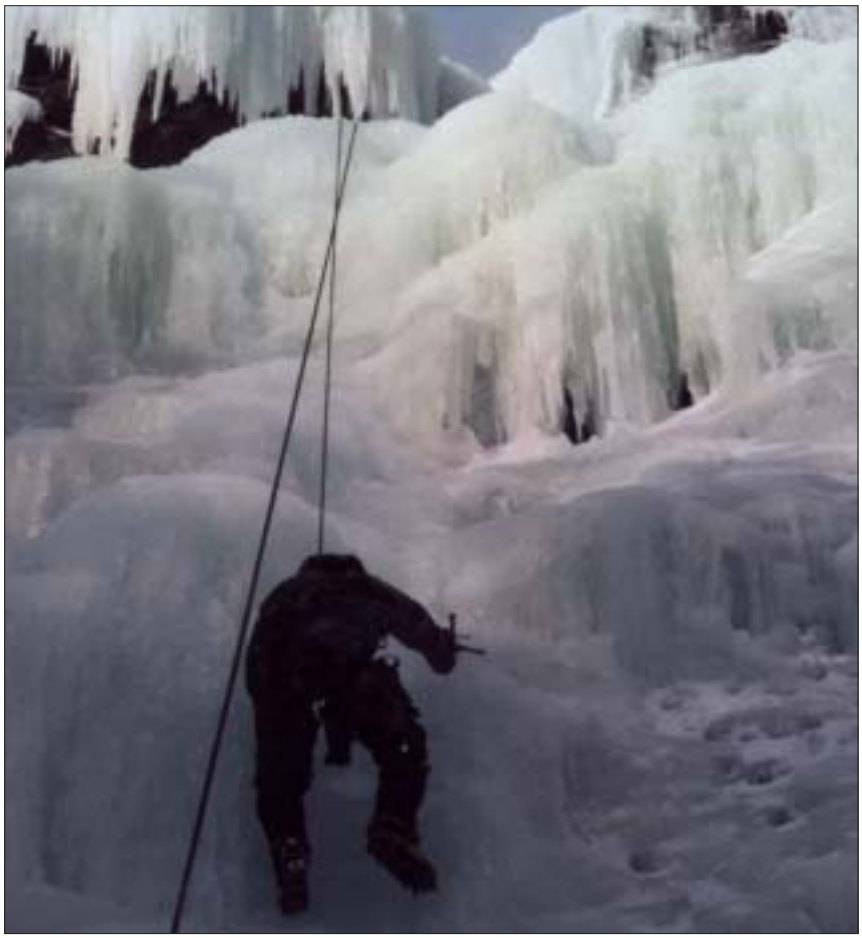
The course is made possible through a program called Scientists and Engineers Field Experience With Soldiers (SEFEWS). The Army Materiel Command-managed program allows civilian employees engaged in or responsible for materiel or weapons research and development programs to acquire a first-hand knowledge of the soldier's environment and equipment. Training opportunities at different installations are available.

The Vermont school offers two-week courses on how to travel and operate effectively in mountainous terrain.

"The school is an excellent opportunity for Natick civilian engineers and scientists to learn about the real-world use of Army clothing, food and shelters," said Gibson. "The winter course seems to be less physically challenging than the summer course, but requires more mental attention to detail and planning."

Shaffer agreed that the course was a great chance to get hands-on experience with the Army's clothing and food, and was pleased with the overall experience.

"The MWS course offered excellent training for working in the mountains, which was enhanced by the knowledgeable staff," Shaffer said. "The staff displayed immeasurable patience while teaching the students."



Courtesy photo

Phil Gibson, a materials research engineer with the Materials Science Team, climbs a wall of ice during the winter class at the Mountain Warfare School in Vermont.

The main focus of the course is mobility. Movement in deep snow and over ice is taught through snowshoeing, cross country and downhill skiing, ice climbing, rappelling, crossing over fixed ropes and skijoring—being pulled on skis by a vehicle.

Instruction includes land navigation with compass and altimeter, glacier travel and crevasse rescue techniques, avalanche hazards and rescue techniques, cold weather injuries and route planning, cold weather effects on weapons, and how to dress for different winter conditions, such as a dry or damp cold.

"Our group was about 10,000 years too late to travel on glaciers in Vermont," Gibson said.

Much of the training is centered on the Ahkio Tent and Stove group, including the Ahkio sled. The winter course culminates in a three-day bivouac in Smuggler's Notch on Vermont's highest mountain, Mount Mansfield. Students hike up into the Notch with their Ahkio sleds and establish a winter campsite with 10-man arctic tents and arctic stoves.

The class is then tested on ice

climbing, installing winter fixed ropes and constructing a U-pulley crevasse rescue system.

Small groups of four to five people travel as rope teams and climb up a ridge, moving on fixed ropes over steep terrain, traversing and rappelling on steep slopes, and reviewing techniques such as self-arrest with the ice axe, movement over steep ice with crampons and glissading.

Students can leave during the course only if they quit, fail or get recalled to their unit. Civilians should be in good physical condition—they must pass the Army Physical Fitness Test and a medical examination to qualify before signing up—and must be prepared to be treated as a soldier for the entire training period.

Participants in their classes included Special Operations Forces members, infantrymen, airmen, National Guardsmen and even Canadian Ontario Provincial Police constables.

Failure rate for the winter course was about 10 percent compared to 25 percent failure rate for the summer course Gibson attended. Shaffer said nobody failed the testing in his class, but a few participants dropped out because of injuries. Students need to score at least 800 out of 1,000 points on physical and written tests to graduate.

"The MWS instructional cadre seem to be very pleased to see Natick civilians taking their course, and I believe they will welcome future attendees from Natick," Gibson said.

Editor's Note: This story was compiled from trip reports submitted by Phil Gibson and Chris Shaffer.

For Natick scientists and engineers interested in participating in SEFEWS, contact John Lupien, Operational Forces Interface Group representative for the SEFEWS program.

Courtesy photo

Participants at the Mountain Warfare School in February set up the 10-man arctic tent and Space Heater, Arctic.

Civilians give impressions of issued military gear

Finding out what it's like to live with equipment designed for and issued to the military is a major benefit of the Scientists and Engineers Field Experience With Soldiers (SEFEWS) program.

Natick engineers Phil Gibson and Chris Shaffer lived with many products that have their roots at the Soldier Systems Center while participating in the winter course at the Mountain Warfare School in Jericho, Vt.

"All in all, the soldiers were satisfied with the quality and usefulness of their equipment," Shaffer said.

Snow hiking was more difficult than expected with Army snowshoes, according to Gibson. Shaffer added that they were bulky and difficult to put on even if sized correctly. Both classes were shown the Marine Corps snowshoes, which have a modern design and possibly better performance.

To protect their hands, most soldiers and instructors brought their own gloves, mittens and liners. The Army gloves need better warmth and water resistance, according to Shaffer. "Less bulk and better tactility is very important when tying a 7 mm cord in cold conditions," he said.

As for insulating the rest of their body, Special Forces troops "raved about" the Special Operations Forces Personal Equipment Advanced Requirements (SPEAR) lightweight environmental protection system, said Shaffer.

Older items, such as the liner for the jacket and pants, were liked because they are compressible and easily removed from a pack when needed.

The instructors were wearing new parkas and trousers, which incorporated new features such as more pockets with waterproof zippers and a stowaway hood.

The new items seemed more appropriate for cold weather use than the existing Gore-Tex parka and trousers, said Gibson.

Students in the Mountain Warfare School courses sleep in tents while on bivouac. For warmth, Shaffer's group was able to evaluate a developmental heating stove from Natick.

"It was easy to operate and cooled down quickly, which made it less time-consuming to prepare it for packing in the Ahkio. Reduced time to complete a task in the cold is very critical," said Shaffer.

Gibson said the Space Heater, Arctic was a "big hit." It was easy to use and maintain, versatile and fairly safe. In the 10-man arctic tent, food was easy to prepare with the stove and kept the tent comfortable.